

Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

Have later edition

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1722

GROWING ALFALFA



ALFAFALFA is a perennial legume belonging to the same family as peas, beans, and clover.

The leading commercial varieties of alfalfa in the United States are the Common, Grimm, and Peruvian. Grimm alfalfa is superior to the Common in the North, and less hardy varieties are preferable for the South.

Alfalfa succeeds best in a dry climate where water is available for irrigation. The best soils on the farm should be selected for the alfalfa field. It is practically useless to attempt to grow the crop on nonproductive lands to improve them.

It is best to precede alfalfa for a year or two with some cultivated crop, such as corn, potatoes, or cotton, to free the land from weeds. The ideal seed bed is a well-settled subsurface with a fine surface that is loose to a depth of 2 inches.

Alfalfa should be sown early enough to permit the plants to become well established before winter sets in. The rate of sowing depends upon the condition of the soil. In the East 15 to 20 pounds per acre is generally advised. In the West, under irrigation, 15 pounds is sufficient, while under dry-land conditions 8 to 10 pounds is ample. Except under very favorable conditions alfalfa should be sown without a nurse crop.

Except where alfalfa is grown under irrigation there is little to be gained by harrowing broadcast fields so long as the stand is satisfactory and the plants are making a good growth. Attempts to thicken up thin stands by resowing or other means nearly always result in failure.

Stands are maintained longer and the yields are generally larger where cutting is delayed until the plants are well in bloom. Hay of a higher feeding value is obtained from cuttings made at the bud or early bloom stage.

Alfalfa hay and pasture are readily eaten by all classes of farm animals.

Alfalfa produces seed in paying quantities only when the rainfall is comparatively light. The average yield per acre runs from 2 to 4 bushels.

This bulletin is a revision of and supersedes Farmers' Bulletin 1283, How to Grow Alfalfa.

GROWING ALFALFA

By H. L. WESTOVER, *senior agronomist, Division of Forage Crops and Diseases,
Bureau of Plant Industry*

CONTENTS

	Page		Page
Introduction.....	1	Cultivating alfalfa.....	22
Acreage.....	1	Making alfalfa hay.....	23
Varieties.....	3	Uses of alfalfa.....	25
Seed.....	5	Seed production.....	26
Climatic and soil relations.....	7	Breaking alfalfa sod.....	26
Choosing a field for alfalfa.....	8	Weeds.....	27
Preparation for alfalfa.....	8	Diseases.....	27
Sowing alfalfa.....	12	Insects.....	28
Instructions for growing alfalfa, by sections.....	17	Rodents.....	30
Treatment of stands.....	21		

INTRODUCTION

ALFALFA (*Medicago sativa* L.) is a herbaceous perennial legume belonging to the same family as peas, beans, and clover (fig. 1). Its flowers are borne in loose bunches, or racemes, and are of a purplish color. The pods in which the seed is produced are twisted spirally in one or two turns, similar to the shell of a snail. Each pod contains several small kidney-shaped seeds. The stems, which are usually not more than one eighth of an inch in diameter, are erect and commonly reach a height of 2½ feet. They arise from a semiwoody base known as the crown. The root system is characterized by a distinct taproot, which in permeable soil extends to a considerable depth. The taproot has few to many branch roots. The leaves are in threes, like clover, and are arranged alternately on the stem.

It is generally believed that alfalfa originated in southwestern Asia, though forms from which it might have sprung are found in China and Siberia. Historical accounts indicate that it was first cultivated in Persia. From there it was taken to the Mediterranean countries and finally to North America. The first recorded attempt to grow alfalfa in the United States was made in Georgia in 1736, but it was not until about 1850, when alfalfa was taken to California from Chile, that its rapid extension began in this country.

ACREAGE

Alfalfa is one of the most important forage crops in the United States, exceeding in acreage any of the other perennial crops grown for this purpose with the exception of timothy alone or mixed with red clover.

Its culture has extended very rapidly since it was first grown successfully in the West. According to the United States census reports the acreage devoted to it practically doubled each 10 years

between 1899, when there were 2,094,011 acres, and 1919, when this crop occupied 8,624,811 acres. In 1929 the area in alfalfa amounted to 11,515,811 acres, which represents an increase of 33.5 percent over the 1919 acreage.

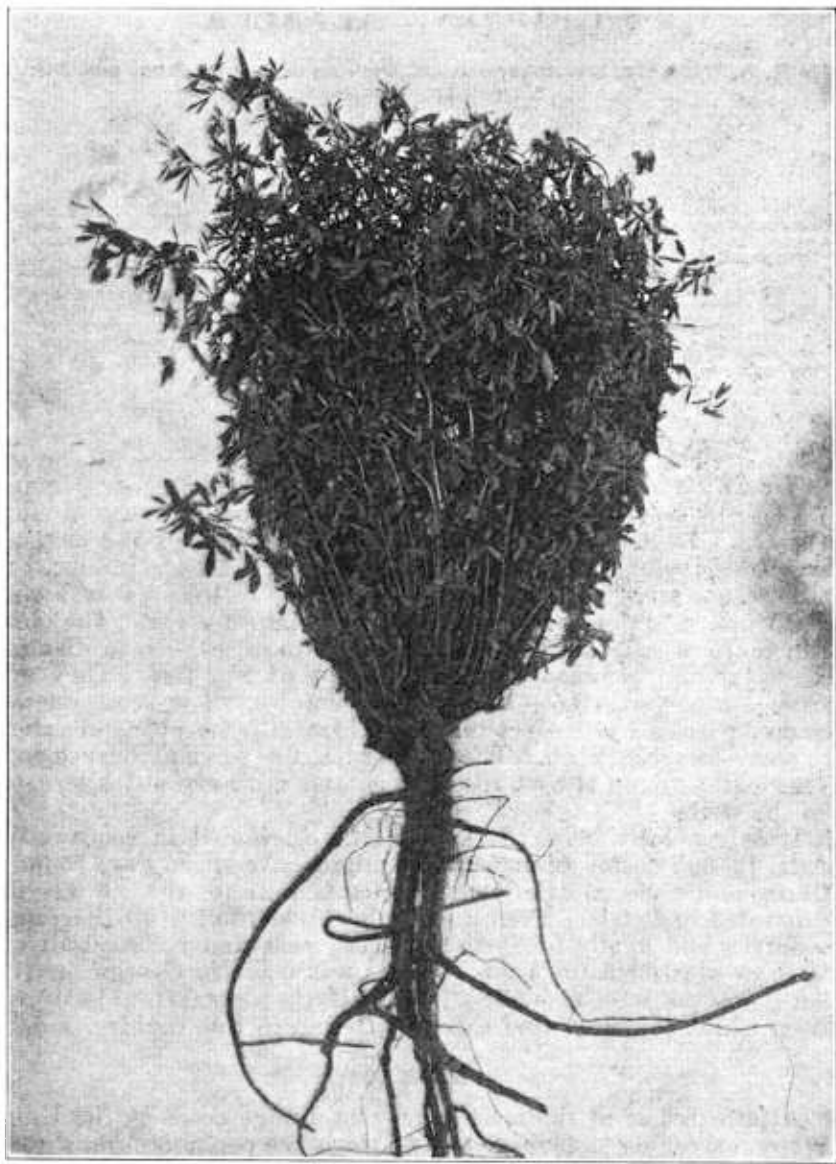


FIGURE 1.—A typical alfalfa plant.

By far the greater part of the alfalfa acreage is west of the Mississippi River although the proportion east of the river increased from about 1 percent in 1899 to a little more than 17 percent in 1929. Although the acreage south of the Kentucky-Tennessee

line increased somewhat, the decided increase in acreage north of that line is largely responsible for the percentage of increase east of the Mississippi River. The actual increase in acreage east of the river between 1919 and 1929 was only about 340,000 acres less than the increase west of the river. This condition was probably the result in part of the spread of the bacterial wilt in the West and in part of the high freight rates which increased the price of hay in the East to such an extent that more attention has been given to local production. Nebraska led in acreage in alfalfa in 1929. Other States in order of acreage included South Dakota, Colorado, California, Idaho, Montana, and Kansas, all with well over half a million acres. Kansas dropped from first to seventh place during the period 1919 to 1929. The total production of alfalfa hay for the United States in 1929 was 23,493,505 tons, the average acre yield being slightly more than 2 tons. This ranged for the different States from a little more than 1 ton to about $3\frac{1}{2}$ tons per acre. In general, the highest average yields were obtained in States where most of the crop was grown under irrigation. California led with an average yield of $3\frac{1}{2}$ tons per acre.

VARIETIES

The commercial varieties of alfalfa in the United States consist of the regional strains of common alfalfa; the variegated group, including the varieties Grimm, Cossack, Baltic, Canadian Variegated (also known as Ontario Variegated), Hardigan, and Ladak; the Turkistan group, including commercial Turkistan and Hardistan; and the nonhardy Peruvian alfalfas.

Common alfalfa includes the greater part of the alfalfa grown in this country. Much of it traces originally to seed that was brought to California from Chile about 1850, and for this reason is frequently referred to in Arizona and California as Chilean alfalfa. The seed from the various States or sections is usually designated by the name of the State in which it is grown. Common alfalfa varies considerably in hardiness and other characteristics, depending upon the conditions under which it has been produced. Where it has been grown for several seed generations in the North it has acquired characteristics which render it more resistant to winter-killing than where it is grown southward. In purchasing seed, therefore, an effort should be made to procure it from a source where the winters approximate in severity those where the seed is to be sown. In the southeastern one fourth of the United States, seed of common alfalfa grown in Kansas and at similar latitudes generally has given larger yields of hay and for this reason is usually more desirable than seed produced in the Northern States.

The alfalfas of the variegated group are generally recognized as being hardier than the common alfalfas. They are the result of a natural cross between the well-known purple-flowered alfalfa (*Medicago sativa*) and the yellow-flowered species (*M. falcata*). They owe their superior hardiness in part to the presence of the yellow-flower blood in their ancestry and in part to the natural selection that has taken place under the severe climatic conditions to which they have been subjected. The variegated alfalfas are recommended for the Northern States, where the winters are severe. Southward, where winter-killing is not a factor to be considered, certain strains of

common alfalfa will ordinarily give somewhat larger yields, and the seed is usually cheaper.

Grimm alfalfa is the best known and most extensively grown variety in the variegated group. It was brought to this country from Germany in 1857 by Wendelin Grimm and was grown for several years in Minnesota before the attention of the public was called to its superior hardiness. Owing to its cold-resistance, its culture is confined pretty largely to the northern half of the United States, where the winters are severe.

Cossack alfalfa was introduced into the United States from Russia through the efforts of the United States Department of Agriculture in 1907. In tests this variety has given results comparable to Grimm alfalfa, but it is grown on a much smaller scale.

Baltic alfalfa takes its name from Baltic, S.Dak., near which town it was grown for several years. In yield and adaptability this variety compares favorably with Grimm but has not given evidence of being superior. It has not been extensively grown, and the seed supply is rather limited.

Canadian Variegated alfalfa is quite similar in appearance and adaptation to Grimm alfalfa. In the northern humid States it has given results comparable to Grimm, but in tests in the northern Great Plains it has not appeared quite so hardy nor as productive. Practically all of the seed sown in the United States is produced in Canada. Under regulations promulgated in pursuance of the Federal Seed Act, 1 percent of each lot or shipment must be stained violet before it is permitted entry into this country.

Hardigan alfalfa is a selection from Baltic made by the Michigan Agricultural Experiment Station for superior hay and seed production. In numerous tests in various parts of the United States it has compared favorably with the other variegated alfalfas but has shown no evidence of being materially superior in cold resistance and productivity.

Ladak alfalfa was imported through the efforts of the United States Department of Agriculture from northern India in 1910. It has given excellent results in the northern Great Plains. It is hardier and more drought-resistant than other alfalfas of the variegated group and has the further advantage of being somewhat resistant to the bacterial wilt.

Turkistan alfalfa was introduced into the United States in 1898, and at one time most of the imported seed came from Turkistan. In recent years, however, comparatively little Turkistan seed has reached this country. Turkistan alfalfas vary in their reaction to cold and bacterial wilt, but recent tests indicate that seed from the most important seed-producing districts in that country is generally equal or superior to Grimm alfalfa in hardiness and is also resistant to bacterial wilt. In numerous tests in various parts of the United States Turkistan alfalfa has usually been less productive than some of our domestic alfalfas. It has given fairly good results in the central and northern Great Plains and may be used to advantage in that area where wilt is prevalent, especially if the grower desires to retain the stands several years.

In the East and South, however, Turkistan alfalfa has given very unsatisfactory results owing to its tendency to become dormant early

in the fall and to its susceptibility to yellowing and to certain leaf diseases which result in the shedding of many of the leaves before the alfalfa has reached the most desirable stage for harvesting. Under regulations governing the enforcement of the Federal Seed Act, 10 percent of Turkistan alfalfa seed must be stained purple-red before it is permitted entry.

Hardistan is the name given by the Nebraska College of Agriculture to an alfalfa which is undoubtedly of Turkistan origin and which first attracted attention by its apparent resistance to wilt and cold. It is very similar to some of the better commercial importations from Turkistan as regards resistance to cold and wilt, susceptibility to leaf diseases, tendency to early dormancy, and productivity. While the variety is promising where wilt is prevalent in the upper Mississippi and Missouri Valleys, preliminary tests indicate that it is not likely to prove more satisfactory in the East and South than most of the commercial lots from Turkistan. The seed supply is at present very limited, but efforts are being made to increase the seed for sowing in areas where wilt is destructive.

Kaw alfalfa, recently so named by the Kansas Agricultural Experiment Station, is undoubtedly of Turkistan origin and behaves in all respects like other alfalfas from that source. It is not likely to be of any particular value in the East or South. Seed is not yet commercially available, though efforts are being made to increase the supply.

Peruvian alfalfa is the least hardy and most rapid growing of our commercial varieties. It was introduced into the United States from Peru in 1899. It seldom survives the winters where the temperature falls below 10° F. and is therefore suited only to the extreme South and Southwest. Where it survives the winters, Peruvian alfalfa gives somewhat larger yields than most other varieties. Two strains of Peruvian alfalfa are recognized, the smooth-leaved Peruvian and the hairy Peruvian. The latter usually produces somewhat heavier yields of hay than the former and is therefore preferable. A more detailed discussion of these alfalfas, as well as of others of less importance, will be found in Farmers' Bulletin 1731, entitled "Alfalfa Varieties in the United States."

SEED

Before buying alfalfa seed there are three points upon which the purchaser should have information: (1) The name of the variety, (2) the section of the country in which it was produced, and (3) the quality of the seed with regard to germination and purity. Unfortunately, it is not possible to distinguish between varieties or strains of alfalfa by the appearance of the seed, and at times, owing to misrepresentation, intentional or otherwise, farmers have had more or less difficulty in obtaining seed of the kind of alfalfa desired. This situation, however, has been remedied to a considerable extent, and now by observing proper precautions the grower may be reasonably sure of the variety and origin of the seed he purchases.

Several State agencies register and certify alfalfa seed as to variety, each package bearing a tag to this effect. Varieties so registered and certified include Grimm, Baltic, Cossack, Ladak, Hardigan, and in some States seed from fields of common alfalfa of long

standing. The United States Verification Service verifies the origin or place where the seed was grown without regard to the variety, and each package of such seed bears the United States verification tag.

An amendment to the Federal Seed Act requires that certain percentages of all lots of imported seed be stained before it is permitted to enter the United States, the color depending upon the adaptability of the seed as determined by tests conducted in this country. Seed from Canada has been found suitable for growing in the United States; 1 percent of it is stained violet. Ten percent of seed from Africa is stained red, as it is not adapted. Ten percent of seed from Turkistan is stained purple-red, and 10 percent of that from South America orange-red, indicating that such seed is of value in restricted areas. Ten percent of imported seed of unknown origin is stained red, while 1 percent of foreign seed of known origin, the adaptability of which has not as yet been determined, is stained green.

The viability of the seed, or its ability to germinate, is quite clearly indicated in its appearance. Plump seeds of a bright olive-green color almost invariably germinate well, while shriveled seeds or seeds that are of a brownish color usually germinate poorly. Alfalfa seed turns reddish brown with age, and while some viable seed may possess this color, such seed should not be purchased without a germination test, even if it is offered at a price materially less than that asked for seed of a fresh olive-green color. When a germination test is desired it can be made by placing 100 seeds between cloths or blotting paper and keeping them moist and at a temperature of about 70° F. After 5 or 6 days most of the readily viable seeds will have sprouted. There will be some, however, that will remain hard, especially if they are of the variegated varieties. Many of these hard seeds will grow when put in the ground, and therefore they should be considered in estimating the percentage of germination. The Department of Agriculture, through its main seed laboratory and branch laboratories, is prepared to make a limited number of germination tests free of charge, but in order to prevent delay beyond the seeding time samples should be mailed to the Department at least 2 months in advance.

With regard to the purity of alfalfa seed, every farmer should be able to recognize readily the most important weed seeds and other impurities that are commonly found in it. Seed to be acceptable should contain not more than 2 percent of impurities. At the present time there is almost no attempt to adulterate alfalfa seed in this country, but every lot should be carefully examined for seed of noxious weeds, especially dodder, before it is purchased. The seeds of dodder are smaller than those of alfalfa, more nearly round, and have a pitted surface which can be detected only by the aid of a lens. As dodder is a troublesome weed and its seed cannot readily be separated from alfalfa seed, dodder-free seed should be demanded by the purchaser. Seeds of buckhorn should always be looked for when samples of alfalfa seed are examined before purchasing. These seeds are shiny brown in appearance, boat shaped, and about twice the length of the alfalfa seed. Seeds of Russian knapweed should also

be searched for carefully, as their presence indicates seed of the imported Turkistan variety. Russian knapweed is now occasionally found in some localities producing alfalfa seed in the United States, and its seed is likely to be found in domestic-grown alfalfa seed. While the Division of Seed Investigations, Bureau of Plant Industry Department of Agriculture, is prepared to make a purity analysis of a limited number of samples free of charge for private individuals, it is very desirable that every farmer acquaint himself with the impurities and noxious-weed seeds that alfalfa seed commonly contains, in order that there may be no serious delay in purchasing seed for sowing.

CLIMATIC AND SOIL RELATIONS

The wide distribution of alfalfa in the world indicates a remarkable adaptability to climate and soil. While the crop requires considerable moisture to produce profitable yields of hay or pasture, it does best in a relatively dry atmosphere where water is available for irrigation. It is not as well adapted to humid conditions. In the United States it succeeds at altitudes ranging from below sea level in the Imperial Valley, Calif., to 8,000 feet in the mountains of Colorado. It withstands hot weather well but is seriously affected by the cold weather of winter and early spring. To what extent extremely low temperatures alone are responsible for the death of alfalfa plants during the winter is not known, but this, together with other winter conditions, commonly results in high mortality. On poorly drained clay soils alternate freezing and thawing, such as occur in many sections, frequently do much damage to alfalfa by heaving the plants out of the soil and incidentally breaking the roots 6 or more inches from the crown.

Deep loam with open porous subsoils are undoubtedly best for alfalfa, but where other conditions are favorable the plant has a very wide range of adaptation insofar as soils are concerned. On account of the deep, penetrating character of its root system alfalfa does not thrive on a soil that has an impervious subsoil, hardpan, or bedrock near the surface. Instances have been observed, however, where it made satisfactory growth on soils underlain at 18 inches by limestone ledges.

Good surface drainage and underdrainage are both necessary if alfalfa is to thrive. During the growing season complete submergence for 24 or 48 hours may do considerable injury, but when the plants are dormant they may remain under water several days with no serious damage. The formation of ice sheets on alfalfa fields during the winter months may result disastrously. It is sometimes possible to reduce the amount of damage to a minimum by breaking up the ice sheets with a disk or in a similar manner. Alfalfa seldom succeeds where the water table comes close to the surface, especially if the level of the water table fluctuates considerably.

In the eastern part of the United States rich river bottoms and soils of limestone origin are best suited to alfalfa, provided they are well-drained. There, where the climatic conditions are not generally favorable, only the best soils available should be devoted to the crop. On strongly alkali soils, such as are frequently found in the West, alfalfa makes little or no growth.

CHOOSING A FIELD FOR ALFALFA

In selecting land for alfalfa careful consideration should be given to the texture of the soil, its productivity, and drainage. Where possible, very sandy or very compact soils should be avoided. The character of the subsoil requires special attention. It is a waste of time and money to attempt to grow alfalfa on land that is underlain at shallow depths by hardpan or other impervious strata. The soil auger is of considerable assistance in determining the character of the soil and subsoil and should be used freely.

The most productive soils on the farm should be selected for alfalfa. It is practically useless to attempt to grow the crop on lands that are nonproductive with the idea of building them up, as is often done. Where good drainage does not exist naturally, it must be supplied by artificial means before alfalfa can be expected to succeed. Tile drains placed 3 feet below the surface will ordinarily lower the water table sufficiently to insure the satisfactory growth of alfalfa, other conditions being favorable. Complaints are occasionally received of tile drains being clogged by alfalfa roots, but this occurs so seldom that it need be given little consideration.

PREPARATION FOR ALFALFA

THE PRECEDING CROP

Alfalfa may be successfully grown after almost any crop provided proper attention is given to the preparation of the soil after the preceding crop has been removed. In deciding upon the preceding crop, however, one should be chosen that fits best into the particular system of farming and at the same time leaves the land in good condition for alfalfa. Due consideration also should be given to the time available for preparing the seed bed for alfalfa after the preceding crop has been harvested. As the young alfalfa plants are very tender and are likely to be killed by weeds during their early stages of growth, it is best to precede the alfalfa for 1 or 2 years with some cultivated crop. Corn or potatoes in the North and corn, tobacco, or cotton in the South serve this purpose admirably. In the Southern States crimson clover or rye and vetch may be sown after the removal of any one of these cultivated crops. The cover crop should be plowed under or cut for hay the following season and the land prepared for alfalfa. Where late summer or early fall sowing is practiced, canning peas, early potatoes, and early sweet corn leave the land in excellent shape, and little further preparation is required. The heavy application of fertilizers which these crops require in many parts of the country will usually suffice for alfalfa. Except in the extreme North small-grain stubble may usually be worked up in time for late summer sowing provided the land has previously been treated so as to destroy the weeds. The chief objection to such a practice is the possible lack of moisture in the soil, due to the demands of the grain crop and the hot weather of summer. Crops that smother the weeds, such as cowpeas, may be used to precede alfalfa to good advantage. In the East it is not usually advisable to sow alfalfa on sod land, but in the Great Plains area this is done with a considerable degree of success.

PREPARING THE SEED BED

The tender nature of the young alfalfa plants requires that the soil be in excellent tilth at sowing time. Many of the failures to secure a good stand may be traced directly to a poorly prepared seed bed. A desirable condition is a well-settled subsurface and a fine surface that is loose to a depth of at least 2 inches. Such a condition is best obtained by plowing the land in the fall, disking in the spring, and harrowing occasionally to keep down the weeds until sowing time. Where fall-plowing is not practicable the land should be broken at least several weeks in advance of sowing. Meantime the soil should be disked and harrowed at frequent intervals to settle the seed bed. The cultipacker will be of considerable assistance in getting the soil into the desired condition. In the northeastern one fourth of the United States, where alfalfa is sown the same season after the removal of a crop of small grain, it is generally better to avoid plowing except on the heavier soils, as there is seldom sufficient time for the soil to become properly settled before sowing. If such land is well-prepared for the grain crop, a thorough disking followed by one or two harrowings will ordinarily leave the seed bed in fairly good condition. Land that has been in early potatoes, peas, or sweet corn can usually be prepared satisfactorily by removing the vines or cornstalks and harrowing. In preparing clover sod for alfalfa the land should be plowed as soon as the crop is removed and disked and harrowed until a firm fine seed bed is obtained. The preparation of sod land may be facilitated by cutting the sod with a disk before plowing. In semiarid regions summer-fallowing is often practiced to insure satisfactory moisture conditions for the seedlings the following spring. This method is also effective in any section for ridding the ground of weeds, but it involves considerable expense.

LIMING

No other of our commonly grown forage crops requires so much lime as does alfalfa. It is necessary not only to have enough to neutralize the soil but also an excess for the actual use of the plant. If there is any doubt about the need for lime, the question should be definitely settled before time and money are wasted in an effort to get alfalfa started. Litmus paper, which can be obtained at any drug store, is a simple though not always an infallible test of the need for lime. Since the lime requirements of soils vary so widely, the prospective grower of alfalfa would do well to seek more exact advice on the probable need for lime from his county agricultural agent or State agricultural experiment station.

In the humid East it is safe to assume that all soils except those of limestone origin will require lime for alfalfa. Even limestone soils are often acid at the surface, and lime must be applied before alfalfa will succeed on them. Limestone soils that do not require additional lime occur in the black belt of Alabama and Mississippi and near Syracuse, N.Y., while limestone soils that need lime are found in the Shenandoah Valley. With the exception of the soils of the Pacific slope of the northwestern part of the United States, which have a high lime requirement, most of the soils west of the ninety-fifth meridian do not require liming for alfalfa.

There are several different forms of lime on the market, such as burned lime, slaked or hydrated lime, ground limestone, oyster shells, and marls. Experiments have shown little difference in the final results from the use of different forms of lime provided an equal quantity of calcium oxide was supplied. Burned or hydrated lime may give quicker results, but ground limestone will eventually bring the same benefit. For correcting acidity, 1 ton of burned lime is equivalent to $1\frac{1}{2}$ tons of slaked lime or 2 tons of ground limestone. Marls vary so in composition that a chemical analysis of the material from each source is necessary to determine the percentage of calcium oxide.

The quantity of lime required depends upon the soil, but ordinarily is not less than 1 ton of burned lime or the equivalent of this in other forms of lime. In some cases much larger quantities are required.

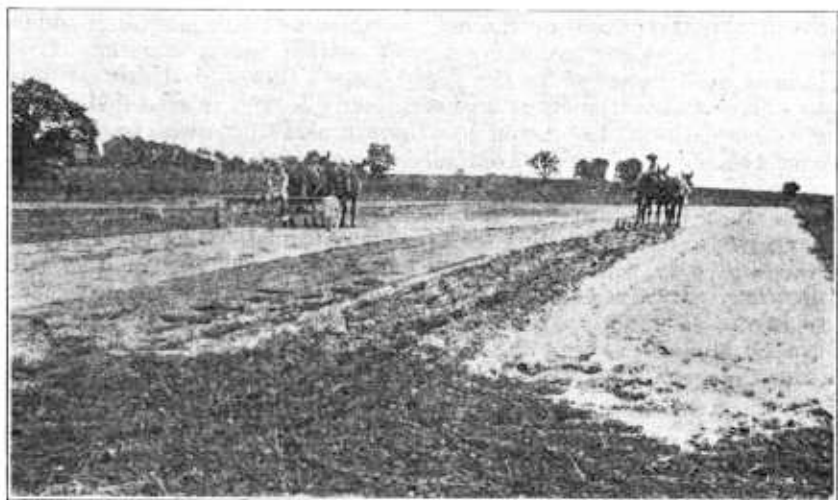


FIGURE 2.—Liming for alfalfa.

The farmer should use whichever is cheapest, based upon the relative proportion of calcium oxide, which is the essential element so far as correcting acidity is concerned. Where the consumer pays the freight he should bear in mind that he not only will have to pay such charges on twice as much ground limestone as on burned lime but also will have the additional expense of hauling and spreading 2 tons of the former to 1 of the latter to get the same benefit.

Where practicable it is well to apply part of the lime the season previous to sowing the alfalfa. This is particularly advisable where ground limestone or oyster shells are used, as the lime in this form is not so readily available as is the burned lime. Where it is not convenient to apply any part of the lime the preceding season, it may be applied after plowing, preferably 3 or 4 weeks before the seed is to be sown, and thoroughly incorporated with the soil. The lime may be applied with a manure spreader, a fertilizer distributor, a lime distributor, or by hand (fig. 2). Any method that spreads the lime evenly and at low cost is satisfactory. Top-dressing an alfalfa stand with lime is not recommended.

FERTILIZING

Alfalfa, being a heavy feeder, requires an abundance of available plant food in the soil for its best growth. In addition to this there should be a liberal supply of humus for the proper development of the nitrifying organisms, without which the crop will in many cases be a failure. On most of the soils east of the ninety-fifth meridian alfalfa responds to some sort of fertilizer treatment. The greatest need seems to be for phosphoric acid and humus, or decaying vegetable matter, and liberal applications of both will in most cases yield profitable returns.

Potash is an essential element, and light applications are beneficial on some clay soils and most sandy soils. Alfalfa requires some nitrogen in the soil for its early growth, but after it is once established, other conditions being favorable, it is able to procure most of its supply from the air by means of the bacteria in the nodules on the roots.

Good barnyard manure furnishes not only humus but also other plant food required by alfalfa and for this reason is one of the most satisfactory fertilizers. It may be applied to the previous crop; it may be applied in the autumn and plowed under prior to sowing alfalfa; or it may be turned under in the spring where fall-plowing is not practicable. It is always well to apply the manure long enough in advance so that it will become well incorporated with the soil. Where the quantity of barnyard manure is limited it may be made to go further by using some superphosphate (acid phosphate) in connection with it. Where it is not available the humus may be supplied by plowing under some green-manure crop and by applying commercial fertilizers. In the North such crops as rye, vetch, and Canada field peas may be used. Farther south bur clover, crimson clover, soybeans, and cowpeas answer the purpose admirably.

If commercial fertilizers are used they should consist largely of superphosphate, about 300 to 500 pounds per acre of 16 percent superphosphate, about 50 to 75 pounds of nitrate of soda to give the alfalfa a start, and 75 to 100 pounds of muriate of potash. The proportion of potash may be increased on sandy soils and decreased or eliminated entirely on clay soils.

Other forms of fertilizer may be used to supply the elements needed by alfalfa, such as cottonseed meal in the place of nitrate of soda and other materials which furnish phosphoric acid. Generally speaking, raw rock phosphate has not given as satisfactory results as superphosphate, since it is much slower in acting than after it has been treated with acid. Most of the experiments that have been conducted in the East indicate that alfalfa is not appreciably benefited by applications of flowers of sulphur.

West of the ninety-fifth meridian many of the soils do not require any special fertilizer treatment for alfalfa. However, there seem to be an increasing number of cases where land that has given good yields of alfalfa for several years when reseeded failed for some reason to give satisfactory results, indicating a decrease in certain plant-food elements. In such cases the use of superphosphate has often proved highly beneficial. On some of the lands of the Pacific Northwest, particularly in Oregon, applications of 50 to 100 pounds per acre of flowers of sulphur have given greatly increased yields.

On the same soils gypsum has increased the yields of alfalfa. In many cases, however, these fertilizers, if they produce any increase in the growth of alfalfa, do not give sufficient increase to justify the extra labor and money involved, and the farmer is advised to avoid any great expense in connection with their use until he has first determined on a small scale whether they will produce any appreciable benefit.

INOCULATION

With the exception of those of the Pacific-coast region of the northwestern part of the United States, most of the soils west of the ninety-fifth meridian are naturally supplied with proper bacteria for inoculating alfalfa. In the eastern part of the country, however, where the soil conditions are less favorable to the growth of nitrogen-fixing bacteria, it is nearly always necessary to supply them at the time of sowing, where alfalfa is grown for the first time. Fields that within the past few years have grown alfalfa, sweetclover, bur clover, or black medic successfully will not ordinarily need further inoculation for alfalfa.

The surest way of getting a new stand of alfalfa well inoculated is to scatter soil from a successful alfalfa field or from the roots of sweetclover or bur-clover plants. In the past the general recommendation has been to use 250 to 500 pounds of soil per acre, the application of which is rather tedious and expensive. In some experiments equal quantities of soil and seed have given good results. This mixture may be sown broadcast or drilled. Where it is drilled in, only finely sifted soil should be used, and as the soil particles are inclined to work toward the bottom of the drill box it may be necessary to add a little occasionally or keep the seed well stirred. Moistening the seed with water to which has been added a little glue and mixing a small quantity of soil with the seed, although not always successful, has in many cases resulted in satisfactory inoculation.

Inoculation is also accomplished by means of artificial cultures, which are put out by most of the State agricultural experiment stations and several commercial firms. Instructions for use accompany these cultures.

The practice of sowing a small quantity of alfalfa with the regular sowing of clover or other hay-crop seed has in some cases apparently been the means of introducing sufficient bacteria for inoculating the succeeding crop of alfalfa.

Investigations indicate that a single inoculation should be adequate for many years, provided the soil is kept well supplied with organic matter and lime, even though alfalfa or sweetclover is not grown on the land. If the soil is allowed to become strongly acid or to lose a large part of its vegetable matter the bacteria decrease very rapidly.

SOWING ALFALFA

METHOD OF SOWING

The method of sowing varies considerably in different sections. It may be done with a grain drill with a seeder attachment or with an alfalfa drill (fig. 3), or the seed may be broadcast with a hand seeder, a wheelbarrow seeder, or by hand and covered with a light harrow, a weeder, or a brush drag. Where the seed is drilled a

somewhat lighter rate is required than where it is broadcast, as better conditions are provided for germination. In order to insure a more even stand, it is best to sow half the seed one way across the field and the other half at right angles to the first sowing. The depth to which the seed should be covered depends on the character and condition of the soil. On heavy soil 1 inch is usually sufficient, but $1\frac{1}{2}$ inches is preferable on sandy soils or on dry soils, to insure getting the seed in contact with moisture. The use of a cultipacker after sowing is of considerable assistance in making conditions favorable for the germination of the seed.

Good results are occasionally reported from broadcasting on honey-combed ground during late winter or early spring, but such a practice can be expected to succeed only under the most favorable conditions and cannot be recommended for general use. In most parts of the



FIGURE 3.—An alfalfa drill.

country it is necessary to cover alfalfa seed, and good results cannot be depended upon if it is left on the surface of the ground, as is sometimes done with grass and clover. In a few instances sowing in corn at the last cultivation has given good stands, and yet it can hardly be termed a safe practice. With abundant rainfall and ideal soil conditions this method sometimes gives good results. The presence of the stubble may be more or less troublesome in the first cutting the next season unless the corn is cut very close to the ground.

TIME OF SOWING

The general principle underlying the time of sowing is to get the seed in the ground as far as possible in advance of what promises to be the most trying season for the young plants. In the northern half of the United States, where rainfall is abundant and soil conditions are suited to alfalfa, seed is often sown in the early spring with a nurse crop. Where sown alone, late spring or early summer sowing is generally best, as this gives an opportunity for preparing a good seed bed and at the same time permits the plants to become thoroughly

established before cold weather sets in. In the Southeast the most favorable time varies from the middle of August in the latitude of Washington to late October or early November along the Gulf coast. February and March sowings are sometimes successful in the extreme South, but late spring and early summer sowings are likely to be crowded out by the weeds.

In the northern part of the dry-farming area of the Great Plains it is almost necessary to sow the seed as early in the spring as the land can be put into shape, since moisture conditions are most favorable at that time. During the summer the soil usually is so dry that the young plants are not able to make sufficient growth to withstand the cold winters. In the southern part of this area, however, good stands are often obtained from late summer and early fall sowings.

In the irrigated districts of the Southwest, October is the best month for sowing alfalfa, although good stands are obtained almost any time between October 1 and April 15. The hot summer months constitute the most unfavorable period. In the North the spring sowings are most satisfactory, although good stands have been obtained where the seed was sown in grain stubble in the late summer or early fall.

RATE OF SOWING

A good stand of alfalfa is highly important from the outset. The quantity of seed necessary to insure a sufficient number of plants per acre varies with different parts of the country and is directly dependent upon the condition of the seed bed. If every seed should grow, 1 or 2 pounds per acre would be ample, but some of them are not viable and others are covered too deeply or else fall in dry soil and fail to germinate. Furthermore, many plants that start to grow succumb in the seedling stage, due to one cause or another. For these reasons it is always advisable to sow a larger quantity of seed than would be necessary under ideal conditions, particularly as the farmer seldom takes the time or goes to the expense of preparing an ideal seed bed. As the cost of the seed is a relatively small item, it is better to waste some by sowing more than is needed than to run the risk of a thin stand that offers a foothold for weeds. In the eastern humid States 20 pounds per acre is sufficient where land is properly prepared, though a heavier rate is sometimes recommended in the South. On most of the soils in the Great Lakes States and in the western part of the humid area 15 pounds of seed is ample. Under dry-farming conditions 8 to 10 pounds of seed is advised, although good stands are sometimes obtained with 4 or 5 pounds. Under irrigation the quantity of seed commonly recommended is 15 to 20 pounds. The heavier rate should be used wherever weeds are likely to be troublesome, as is the case in some parts of the Southwest. In the northern irrigated districts good stands are obtained with 15 pounds of seed.

ALFALFA IN MIXTURES

Because of its ability to produce two or more cuttings in a season alfalfa is not generally well suited to sowing in mixtures with grasses and clovers. Usually mixtures have not yielded much more than alfalfa alone but the presence of grass affords some protection against heaving. In humid districts where more or less difficulty is encoun-

tered in curing alfalfa the presence of some grasses may be of appreciable value in hastening the process, and, furthermore, some feeders prefer mixtures to alfalfa alone. Grasses are sometimes sown with alfalfa for pasturing to reduce the danger from bloat. Timothy is probably used in mixture with alfalfa more than any other grass because of its wide popularity. It is used to some extent in the East and to a considerable extent in parts of the Northwest where alfalfa is grown under irrigation. The mixture is also commonly sown at high altitudes. There are quite a number of farmers in the Northeast who make a regular practice of sowing a little timothy with alfalfa on the theory that when the alfalfa dies out the timothy will fill up the vacant spaces and check the growth of the weeds. Timothy, however, does not thicken its stand under meadow conditions. Orchard grass and meadow fescue are better suited for sowing with alfalfa than is timothy, as they mature more nearly with it.

In the northern Great Plains area, northwestern Missouri, and western Iowa smooth brome grass gives fairly good results when sown with alfalfa. After a few years, however, the brome grass forms such a dense sod that the surviving plants of alfalfa are unable to make a very vigorous growth in it. Kentucky bluegrass is not satisfactory, as it crowds out the alfalfa.

NURSE CROPS

Where a nurse crop can be used without danger of decreasing the chance of securing a stand of alfalfa, it is quite desirable, as it gives some return from the land while alfalfa is becoming established. The chief objections to a nurse crop are that it draws rather heavily on the moisture supply of the soil, and as it is harvested at a hot time of the year the sudden change from the shade offered by it to the bright sun is likely to prove injurious to the alfalfa seedlings.

The practice of making early spring seedings with any one of the small grains where conditions are favorable for alfalfa is becoming more general, and satisfactory stands usually result. The small grains are probably no harder on the alfalfa than the heavy growth of weeds which generally results in early seedings without a nurse crop. Any one of the spring grains, preferably an early maturing variety of flax, may be used as a nurse crop. Such evidence as is available indicates that in regions adapted to flax it is one of the safest nurse crops for alfalfa. It is generally advisable to sow the grain at about one half the normal rate and harvest it as soon as it shows evidence of injuring the alfalfa. Good results have also been reported from sowing alfalfa with winter wheat sown in the spring. In parts of the Northeast satisfactory stands are secured where alfalfa is sown with canning peas as they come off early and are less injurious to the young seedlings than are the small grains. Alfalfa is sometimes sown in the spring in winter wheat or rye, but the results from sowing in such an established crop are less likely to be satisfactory. Wheat or rye ground is often rather compact, and as alfalfa seed must be covered to insure a satisfactory stand, it is necessary to loosen the soil before drilling or broadcasting the alfalfa seed. In some cases it is advisable to follow with a harrow after seeding to insure better covering.

In the dry-farming regions, where moisture is the limiting factor, the use of a nurse crop is almost sure to prove disastrous except in seasons of abundant rainfall. Under irrigation the percentage of successful stands with a nurse crop runs somewhat higher. The practice is quite commonly advised in spring sowings in the northern irrigated districts, but farther south it is considered a better practice to sow the alfalfa alone. The nurse crop is seldom used with late summer or fall sown alfalfa, except occasionally in the Southwest.

GROWING ALFALFA IN ROWS

At one time it was believed that growing alfalfa in cultivated rows would be advantageous in regions of limited rainfall (fig. 4). It was hoped that in such regions it would be possible to produce



FIGURE 4.—Alfalfa in cultivated rows.

satisfactory yields of hay and seed in this way. Farmers as well as investigators of the United States Department of Agriculture and several State experiment stations have given the method a thorough trial. The results of these tests indicate that where the rainfall is not sufficient to produce profitable yields of hay in broadcast or close-drilled fields it is likewise too dry for alfalfa in cultivated rows. Where the rainfall is very limited the yield from rows is somewhat greater than that from the close-drilled fields, but not enough larger to justify the extra expense involved. The cultivation necessary to keep down weeds adds considerably to the expense of growing the crop. Moreover, the hay is of a poorer quality, as it is dusty and contains many small clods of dirt.

With a limited moisture supply alfalfa in rows ordinarily will give somewhat larger yields of seed than close-drilled or broadcast seedings, and under certain conditions this method appears to have

possibilities particularly in the case of an unusual variety, seed of which commands a price sufficiently high to insure a profit in spite of low yields.

INSTRUCTIONS FOR GROWING ALFALFA, BY SECTIONS

MICHIGAN, WISCONSIN, MINNESOTA, NEW YORK, AND THE NEW ENGLAND STATES

In Michigan, Wisconsin, Minnesota, New York, and the New England States the following practices are observed in the growing of alfalfa.

Attention is given to the need for lime, fertilizer, and inoculation, as mentioned on pages 9-12. Land that is intended for alfalfa should be in some cultivated crop, such as corn or potatoes, for 1 or 2 years prior to being sown with alfalfa. The ideal seed bed is obtained by plowing in the fall and completing preparation in the spring. On some soils that have been in a clean-cultivated crop the previous season a good seed bed can be prepared by disking and harrowing in the spring without the necessity of fall plowing. Under favorable conditions good stands follow the practice of sowing the alfalfa seed in the spring with a small grain as a nurse crop. An early maturing variety of grain is preferable and should be sown at the rate of about 1 bushel per acre. In order to conserve moisture it is sometimes advisable to cut the grain for hay just after it has headed. If the grain lodges it should be removed early; otherwise it may smother the alfalfa. Canning peas make an excellent nurse crop, as they are harvested early.

Successful stands are also obtained from sowing the seed alone in June or early July, but when this is done no return is obtained from the land the first year. For this reason most farmers prefer to chance sowing later, after some other crop, such as an early crop of potatoes or early truck, has been removed, as the land requires little preparation for alfalfa provided the vegetable crop has been well cultivated. It is seldom safe to sow alfalfa after a crop of small grain has been removed, as there is barely time for it to become thoroughly established before cold weather, and the moisture supply may be limited, owing to the demands of the preceding crop. Seedlings made later than the middle of August are not dependable, as the alfalfa may not make sufficient growth to withstand the winter.

On land that is well adapted to alfalfa 15 pounds per acre of clean seed that germinates 90 percent is sufficient. Under less favorable conditions 18 to 20 pounds per acre is safer.

OHIO, INDIANA, ILLINOIS, IOWA, MISSOURI, KENTUCKY, PENNSYLVANIA, NORTHERN NEW JERSEY, AND WEST VIRGINIA

On most of the soils in Ohio, Indiana, Illinois, Iowa, Missouri, Kentucky, Pennsylvania, northern New Jersey, and West Virginia, lime, inoculation, and some sort of fertilizer treatment are essential for the best growth of alfalfa. Discussions regarding these features will be found on pages 9-12.

Where the land is well suited to alfalfa the seed is quite commonly sown in the early spring with a small grain sown at about one half the normal rate or occasionally in winter wheat or rye. Better

stands are assured under the former practice. If the nurse crop gives evidence of injuring the alfalfa seedlings, it should be cut for hay. Early canning peas have also been successfully used as a nurse crop. Good results are often obtained where the seed is sown after an early crop of sweet corn, potatoes, or truck. Such land requires little preparation for alfalfa, provided it has been well cultivated. Small-grain crops usually mature early enough for late-summer sowings of alfalfa, but there is very likely to be a deficiency in the soil moisture at this time, due to the demands of the previous crop. An early crop of red clover may also be taken off soon enough to get the land into shape for alfalfa the same year. Such land will require considerable preparation, as it will need to be plowed and thoroughly worked before it is safe to sow alfalfa.

The quantity of seed required varies with the perfection of the seed bed, the character of the soil, and the condition of the weather at sowing time. Under favorable conditions about 12 to 15 pounds per acre has proved sufficient.

If the weather is favorable and the soil in good condition and free from weeds, it does not seem to make much difference when the seed is sown, so long as there is sufficient time for the plants to become well established before winter starts in. During midsummer, however, the weather is usually too hot and the soil too dry to insure the successful germination and growth of the seedlings. It is not advisable to sow much later than the first of September.

THE SOUTHEASTERN STATES AND THE GULF COAST

The soils in the Southeastern States and the Gulf coast region, with few exceptions, are not naturally well-suited to the production of alfalfa, and careful attention must be given to preparing the land for the crop. Consideration should be given to liming, inoculation, and fertilizing, which are discussed on pages 9-12. Weeds are especially troublesome in this section, and for this reason alfalfa should be preceded for 1 or 2 years with crops that are clean-cultivated or with such a crop as cowpeas, which chokes out the weeds. Corn and cotton are good preparatory crops. Early truck and potato crops furnish excellent opportunities for destroying weeds and may generally be taken off the land in time for sowing alfalfa. These crops leave the land in such shape that plowing is not necessary. Red or crimson clover or rye and vetch can be cut up with a disk, then turned under, and the land prepared for the late summer or early fall sowing of alfalfa. A common practice in the southern part of the region is to sow winter grain after a crop of corn or cotton has been removed. The grain is harvested in the spring and the land plowed and sowed to cowpeas as soon as possible. In the latter part of the summer the cowpeas are cut up with a disk, and the land is plowed and prepared for sowing by the latter part of September or early in October. Farther north the same system may be used, but the crop of cowpeas should be cut for hay and the land disked and harrowed for alfalfa. It is not advisable to plow under the cowpeas as far north as Virginia, as there is not time for them to decompose and the land to settle before the alfalfa is sown. In sections where considerable silage corn is produced, successful

stands are sometimes obtained from sowing after the corn is removed.

In this region alfalfa is generally sown without a nurse crop at the rate of 20 to 25 pounds per acre. In the piedmont sections, in the Mississippi Delta, and on prairie limestone soils of Alabama and Mississippi good stands are secured with 20 pounds, but in the Coastal Plains, where the soils are sandy and weeds troublesome, less than 25 pounds per acre is not advisable.

In the northern part of the region under consideration sowings made about the middle of August on an average have given the best results. In the South Atlantic and Gulf States the date of sowing may be delayed with safety until the middle of October, and when weather conditions are especially favorable successful stands are sometimes obtained from sowings made as late as the 1st of November, although they are not recommended. Early spring sowings—that is, in March—are sometimes successful in the extreme South.

SEMIARID CONDITIONS

Alfalfa is grown quite extensively in parts of the West where the rainfall is limited, and where water is not available for irrigation. In this region the soil-moisture conditions are usually most favorable in the spring, and in the North it has generally been considered the best practice to sow as early in the spring as the ground can be put in shape; but recent experiments indicate that, in some sections at least, weeds are less troublesome where sowing is delayed until the 1st to the 15th of May. This gives opportunity to work up the seed bed 2 or 3 times, thus destroying many of the weeds. If sowing is delayed until the weather is hot and dry, there is danger that the plants will not become well enough established to survive the winter. South of Kansas the seed may be sown either in the spring or early fall. Moisture conditions usually are most favorable in the spring, but weeds are likely to prove more troublesome when the seed is sown at this time. For this reason many growers prefer to keep the land cleanly cultivated during the summer and sow the seed in the late summer or early fall.

Preparation for alfalfa should begin somewhat in advance, to insure sufficient moisture for the young seedlings. Where the seed is to be sown in the spring the land should be summer-fallowed the previous year or else devoted to some cultivated crop, such as corn, to assist in freeing it of weeds and to conserve the moisture. Except on heavy soils it will not be necessary to plow again, but where it seems advisable it should be done in the fall and the land disked and harrowed as soon as it is in condition to work the following spring. Land to be sown in the late summer or early fall should be plowed the previous fall and kept cultivated throughout the spring and early summer.

The use of a nurse crop is not recommended under dry-land conditions, as it draws too heavily on the rather limited moisture supply. However, good stands are frequently obtained with one third or one half the normal rate of sowing of some small-grain crop, particularly where it is cut early for hay. Good results are also secured from the use of flax as a nurse crop.

Over most of the dry-farming area less seed is required than is advised under humid conditions or under irrigation, partly owing to the fact that weeds are less troublesome. Ordinarily, from 8 to 10 pounds of seed per acre will be ample. Good stands have been obtained with 2 to 4 pounds, but such light rates cannot be recommended for general practice.

SANDY SOILS

In the Eastern States alfalfa usually does not survive long on very sandy soils, although fairly good yields may be obtained for 2 or 3 years where liberal applications of stable manure are made prior to sowing the seed. West of the Mississippi River such soils, if not too sandy, usually will grow alfalfa successfully after the plants are once well established. However, it is often difficult to start the crop on soils that are so light in texture that they drift badly, as the young plants are likely to be cut off by the sand unless special precautions are taken. This may be avoided by applying a light top-dressing of straw or coarse manure just after sowing. Another method that has proved quite satisfactory is to scatter a thin layer of wild hay or straw from an old stack bottom over the land immediately after the seed has been sown. The field is then gone over with a weighted disk set straight. This cuts the hay into the ground and leaves it standing over the field, much like stubble. Good results are also had where the alfalfa is drilled into high-cut stubble of sorghum or millet. Where cornland is used and the field is in good shape, it may be prepared by disking down the stalks early in the spring and leaving the soil rough until time for sowing. The alfalfa seed may also be sown with about a peck per acre of rye, barley, or some other small-grain crop which will make a rapid growth and protect the young alfalfa seedlings. Unless there is danger of injury from drifting soil the nurse crop should be avoided, as it is likely to draw so heavily on the soil moisture as to injure the alfalfa.

The rate of sowing generally advised is from 10 to 15 pounds per acre. The press drill gives the best results, but where this is not available the seed may be sown broadcast, the land harrowed, and then rolled to get the seed into contact with the moist soil and hasten germination. After rolling, it is best to harrow the soil lightly so as to reduce the possibility of the formation of a crust on the surface.

SOWING ALFALFA UNDER IRRIGATION

In preparing land for alfalfa the first step is to break it deeply and then level it if necessary. Plowing should be done several weeks in advance of sowing, so that the soil may be properly compacted by the use of a heavily loaded disk, a roller, or some other suitable implement. Ordinarily it is best to irrigate the land just prior to sowing the seed; and, as soon as it has dried out sufficiently, the surface should be worked up into a fine mellow seed bed. If possible, further irrigation should be avoided until the plants have developed three or four leaves. Good stands are sometimes obtained where the seed is "irrigated up", but the practice is not recommended, particularly on heavy soils, as the surface often becomes so crusted that the young plants are unable to break through.

For ordinary conditions the rate of sowing should be about 15 pounds per acre, although a smaller quantity may give good stands under ideal conditions. Generally speaking, somewhat less seed seems to be required in the northern irrigated districts than farther south, probably because weeds are somewhat less troublesome. The time of sowing will depend upon frost conditions, but should be early enough to allow the plants to become well-established before cold weather. In the extreme Northern States the best stands are obtained where the seed is sown as early in the spring as it is possible to get the land in condition. Ordinarily, at this time of the year the soil contains considerable moisture as a result of the winter precipitation, and irrigation prior to sowing is not essential. Another advantage of early spring sowing is that during the cool weather the soil does not dry out very rapidly, so that the plants have an opportunity to become well-established before irrigation is necessary. In Montana and the Dakotas the latter part of April or early in May is about the earliest date that alfalfa can be sown safely. Under favorable conditions in these States good stands have been obtained where seed was sown on disked grain stubble in the late summer. In the extreme Southwest good stands may be secured from sowing almost any time between October 1 and April 15, although the December and January sowings are occasionally injured by cold weather. October is the most favorable month, but where it is impossible to get the land in shape in the fall, February and March sowings usually give quite satisfactory results. The hot summer months constitute the most trying period.

As a rule, the best stands are secured where the alfalfa is sown alone. In the Northern States, however, a nurse crop is not particularly objectionable, provided it is sown at about one half or one third the usual rate. In the Southwest it is best to avoid the use of a nurse crop.

TREATMENT OF STANDS

Late summer or fall sown alfalfa requires no treatment that season. Even though the plants make considerable growth before being checked by frost, they should not be cut. Where alfalfa is sown in the spring, weeds usually appear in abundance, and the important question is whether it is better for the alfalfa if the weeds are cut back or allowed to grow. There is a generally prevailing theory that the frequent cutting of young plants forces them to stool out and increases root growth, but carefully controlled experiments have demonstrated quite clearly that such treatment actually checks root development. Even where the weeds are very rank, such evidence as is available indicates that it is better to delay clipping until the young alfalfa plants have reached the proper stage, that is, until they are in bloom. While the earlier clipping may check the weed growth to some extent, it also weakens the alfalfa seedlings and lessens their ability to compete with the weeds.

When the field is cut, the growth should be removed if there is any danger of smothering the seedlings; otherwise it may be left on the ground as a mulch. In the northern Great Plains and intermountain region the weeds in alfalfa have been allowed to go unclipped throughout the first season, the subsequent stand of alfalfa

benefiting by such treatment. Where this is done it is advisable to get rid of the dead growth early in the spring. In the North, where only hardy alfalfas are grown, this has been accomplished by burning over the fields, but the more tender alfalfas are sometimes injured by such treatment. Where it is not safe or convenient to burn off the fields the dead growth may be raked up and hauled off. In the South and Southwest it is often possible to procure two or three cuttings of hay the first year from spring sowings, and where this is the case the recommendations made above do not apply.

Alfalfa should not be pastured at all the first year, and only lightly the second year. It should never be pastured closely, as the grazing-down of the crowns often results in killing the plants. Cattle should never be allowed access to a field when the ground is wet or frozen. Owing to the difficulty of securing a good stand in the East, it is very doubtful whether alfalfa in that section should be pastured at all.

If the stand becomes thin or patchy the field should be plowed up and reseeded after it has been planted to some other crop for a year or more. Attempts to patch up poor stands generally prove futile.

In the East a top dressing of well-rotted stable manure applied in the late fall or winter not only furnishes some protection but in most cases also increases the yield the following season. If stable manure is not available, an application of 300 to 500 pounds of superphosphate per acre in the spring is of considerable assistance in maintaining the vigor of the stand.

CULTIVATING ALFALFA

For many years writers have advocated the disking or harrowing of alfalfa fields, on the theory that it increases the yield and prolongs the life of the stand. While some form of cultivation appears advisable under certain special conditions, any general statement to the effect that alfalfa fields are always benefited by such treatment is certainly open to question. Where irrigation waters leave thick deposits of silt on the field the use of the harrow to break up such deposits appears advisable; also where irrigated alfalfa is pastured, some sort of cultivation to loosen the soil that has been compacted by trampling, particularly the heavy-textured soils, may be beneficial. Where weeds and grass threaten to crowd out the alfalfa the life of the stand may often be profitably prolonged for a year or two by harrowing. Generally speaking, however, there is little or no advantage to be gained by cultivating broadcast alfalfa so long as the stand is satisfactory and the plants are making good growth. Extensive experiments have shown that under such conditions the increase in yield, if any, is not sufficient to pay the additional cost of producing the crop, and the life of the stand is prolonged but slightly, if at all.

The best implement for cultivating alfalfa is the so-called alfalfa harrow, which is a modified form of the spring-tooth harrow (fig. 5). This implement loosens the soil without seriously injuring the plants. The spike-tooth harrow will loosen up the lighter textured soils, but is of little benefit on the heavy soils. Experience has shown that in most cases the use of the disk harrow is actually injurious, as any

implement that has a tendency to split the crowns renders the plant more susceptible to certain diseases.

The best time for cultivating a field of alfalfa will depend upon the object to be gained. Ordinarily it should be early in the spring or immediately after any one of the cuttings. Alfalfa should never be cultivated the first year after sowing, as the plants are so small that they are easily pulled out and killed.

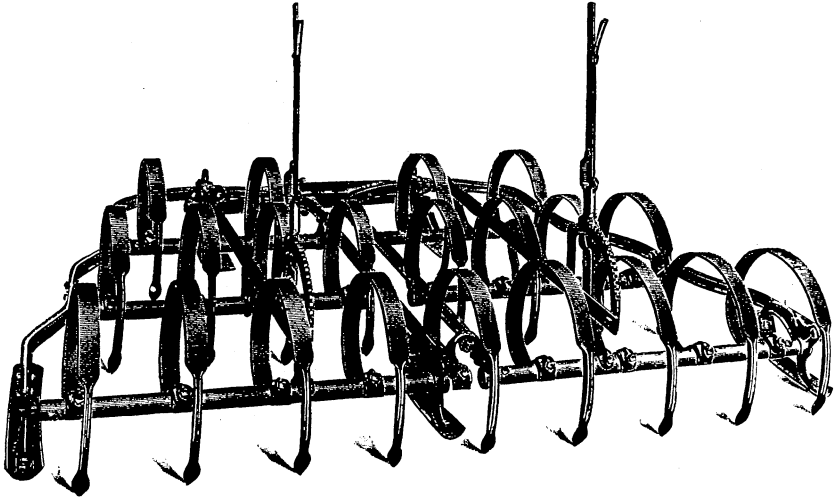


FIGURE 5.—Type of harrow commonly used in cultivating broadcast alfalfa.

MAKING ALFALFA HAY

Most of the alfalfa grown in this country is cut for hay. The number of cuttings obtained depends upon climatic conditions, the soil, and the variety, and varies from 8 or sometimes more in the far Southwest to 2 and sometimes only 1 in the North and semi-arid sections. From 30 to 40 days are required to produce a hay crop.

The stage of growth at which alfalfa is cut has a marked effect on the feeding value of the hay, the life of the stand, and yield. Hay of the highest feeding value results from early cutting owing to the greater proportion of leaves, which contain twice as much protein as the stems. Continued cutting as early as the bud stage, however, has been shown repeatedly to shorten the life of a stand very materially under most conditions. Stands survive longer and yields often are larger where harvesting is delayed until the plants are in full bloom, but this is at the expense of the feeding value of the hay.

Recent experiments indicate that under certain conditions, at least, the first or the first and second growth may be removed at the bud or early-bloom stage without shortening the life of the stand provided one or more of the later cuttings are delayed until full bloom. By following this practice a better quality of hay is obtained from the early cuttings, which are generally rank and coarse. Whether one or more cuttings are removed at the early stage will of course vary with the number of crops obtained during the year. In the East alfalfa blooms very sparingly when the season is too wet

or too dry; therefore it is very difficult to determine the stage of maturity by the flowering. When this is the case the growth of the basal shoots and general appearance of the field should serve as a guide for cutting. If the basal shoots have made considerable growth and if the foliage is beginning to take on a yellow cast, indicative of the slowing up or stopping of growth, the field should be harvested regardless of the percentage of bloom. Under most conditions alfalfa should go into the winter with considerable growth; otherwise winter-killing is likely to occur. When alfalfa is killed back by late spring freezes cutting is advisable without consideration for stage of growth.

As the leaves contain about two thirds of the feeding value of the plant, an effort should be made to get the hay in the stack or mow with as large a proportion of the leaves as possible. The hay should be left in the swath until it is well wilted but not brittle. the length

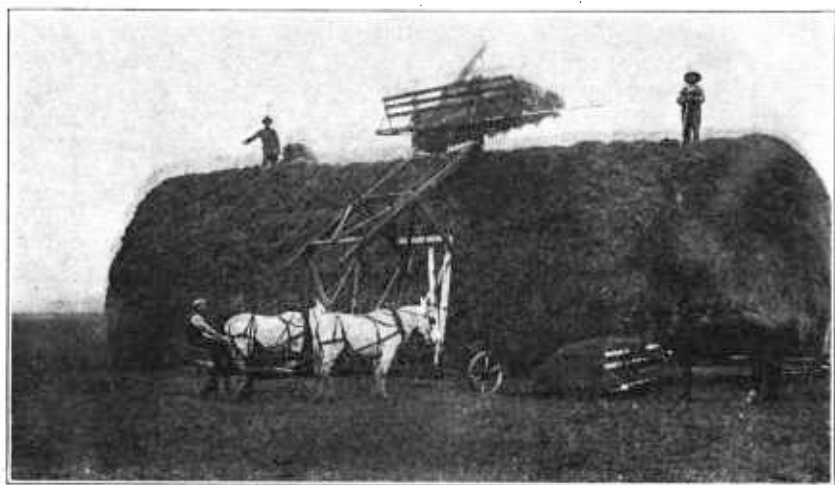


FIGURE 6.—Stacking alfalfa.

of time depending upon the weather and the growth. It should then be raked into a windrow with a side-delivery rake and turned occasionally with the same type of rake to hasten curing. Where the acreage is small, alfalfa is often cured in cocks, occasionally being covered with hay caps consisting of a piece of canvas about 3 feet square, which of course increases the labor and expense very materially and is not practical for large acreages. Where the weather is uncertain, partial curing in the swath and finishing in the windrow is to be preferred, as the hay can often be put into the barn, while that in cocks may be spoiled owing to the longer time required for curing.

The least loss is sustained where the hay is placed in the barn, but in the big alfalfa districts such space is not available, and most of the alfalfa is stacked (fig. 6). Many of the stacks are carelessly built and left unprotected in spite of the fact that the saving effected nearly always justifies some sort of covering and the effort involved in building a well-shaped stack. Canvas, boards, corrugated sheet iron, or

coarse grass may be used to cover a stack of alfalfa. The stacks should be as large as practicable, and in order to shed water properly they should be somewhat larger at a height of 6 feet than at the base. Alfalfa should not be put in the barn too green, as it is likely to heat and in extreme cases has been known to become so hot as to cause a fire. Where hay is stacked before it is properly cured, fermentation takes place, resulting in a brown hay. Experiments indicate that good brown hay is somewhat superior to green hay in palatability but that it is not superior to green hay in feeding value.

USES OF ALFALFA

Well-cured alfalfa is more readily eaten by all classes of farm animals than any other kind of hay. Chemical analyses show little difference in alfalfa hay and that made from certain other legumes,



FIGURE 7.—Dairy cows grazing on alfalfa.

such as cowpeas, soybeans, and clover, but it is generally somewhat more palatable. As a pasture plant alfalfa is relished highly, and fields of it have a large carrying capacity; but if it is utilized in this way considerable caution should be taken, as a good stand is easily injured by overgrazing (fig. 7). Alfalfa should never be pastured the first year and should be pastured only lightly the second year. Ordinarily hogs are less injurious to alfalfa than other classes of livestock. Care should be taken in pasturing sheep and cattle on alfalfa, as they are subject to bloat; horses, mules, and hogs are not.

Good silage may be made from alfalfa, provided the material is finely cut and thoroughly packed, but as ordinarily put into the silo it does not keep as satisfactorily nor as long as silage made from corn. Its chief disadvantages are the labor involved in putting it up and the lack of sufficient tonnage. Where it is possible to make good hay it seldom pays to make silage of alfalfa. Alfalfa makes an excellent soiling crop so far as yield is concerned, but it should be cut no oftener and no earlier in the stage of development than when it is

cut for hay. In parts of the West large quantities of alfalfa are ground into meal. Much of this meal finds its way to the eastern markets either unmixed or mixed with molasses and various feeds. The mere grinding of the hay into meal does not increase its feeding value, but it is fed with less waste and is in convenient form for city and town use. It also gets the benefit of a considerably lower freight rate than hay. Attempts have been made to extend the use of alfalfa to the making of human food, medicines, textiles, dyes, and other commercial products, but the plant has little or nothing to commend it for such uses.

SEED PRODUCTION

Alfalfa produces seed in paying quantities only where the summer rainfall is comparatively light. For this reason the commercial production of alfalfa seed in the United States is confined largely to that portion lying west of the ninety-fifth meridian. Most of the seed of the Grimm variety is produced in Idaho, Montana, North Dakota, and South Dakota. The Peruvian alfalfa seed industry is confined almost entirely to the Yuma Valley of California and Arizona. In abnormally dry seasons considerable seed has been produced east of the ninety-fifth meridian. Ordinarily it is more profitable for the farmer in the Eastern States to purchase seed that is produced in the West than to attempt to grow it himself.

For its best development the alfalfa-seed crop requires a hot, dry season, and as a result it is customary to save that crop for seed which matures during the hottest and driest part of the summer. Over much of the country this is the second crop, but south of Kansas it may be the third crop. In the extreme North the season is usually so short that it is necessary to leave the first growth for seed. For a short time in the spring some growers pasture fields that are to be devoted to seed production.

For a seed crop alfalfa should be cut when two thirds to three fourths of the pods have turned brown. The crop may be harvested with a mower having a bunching attachment or with a binder having the tying attachment removed. This leaves the alfalfa in convenient forkfuls and reduces shattering in handling. Where possible, alfalfa is threshed from the field, but in some cases it is necessary to stack it. An alfalfa huller is the most satisfactory thresher, although the ordinary grain thresher equipped with alfalfa sieves and with the concaves screwed down does quite satisfactory work. The average yield of seed per acre runs from 2 to 4 bushels. The total production of alfalfa seed in the United States during the last 5 years has ranged from approximately 32,000,000 pounds in 1932 to 70,000,000 in 1930. The amount of seed imported during this period was much less than that imported during the preceding period; the greater part of the seed came from Canada.

BREAKING ALFALFA SOD

Farmers often complain of the difficulty of breaking up and destroying a stand of alfalfa, but under most conditions this need not offer any serious objection to the crop provided the necessary equipment is at hand; that is, strong horses and a sharp plow.

The plow should be in good condition when it enters the field, and the operator should carry a file to keep it sharp. It is of course more difficult to keep the plow in condition in gravelly or stony soil.

The furrow slice should be 2 inches less in width than the plow will turn. This is to prevent any of the large roots from slipping by uncut. Sometimes the plows are provided with a knife attachment to the landside to cut the roots near the outer edge of the next furrow. The most successful practice is to plow shallow in the fall and deep the following spring. Where only one plowing is practicable this should be rather shallow. If plowed too deeply the roots frequently retain enough life to start again. Ordinarily it is better to leave the furrow slice to dry out some time before cultivating, as this assists in killing the roots.

WEEDS

In most of the United States weeds constitute the worst enemy of alfalfa. Dodder, a threadlike yellow twining plant which lives as a parasite on plants, is very objectionable in seed-producing districts, as there is little or no market for alfalfa seed that carries seeds of dodder with it, and the two seeds are very difficult to separate. Dodder seldom gives much trouble in fields that are devoted entirely to the production of hay. Other troublesome weeds are Kentucky bluegrass and quackgrass in the northeastern one fourth of the United States; crabgrass and Bermuda grass in the Central and Southern States; and foxtail or wild millet in the Middle West and the Great Plains. In the irrigated sections of the West the wild barleys, also known as foxtail and squirreltail grass (*Hordeum* spp.), are decidedly troublesome, as the beards ruin the first crop of hay for feeding unless it is cut very early. Where weeds are troublesome in the West, wheat is sometimes drilled in the alfalfa in the fall, and as it comes on early the growth of the weeds is checked. The first cutting of hay the following spring consists of a mixture of alfalfa and wheat. Cultivation of established stands of alfalfa may help to hold the weeds in check, but unless done with considerable care the alfalfa may be injured. The most satisfactory way to control them is to make the conditions so favorable for alfalfa that the weeds are smothered out. When they become abundant it is better to plow the field rather than attempt to get rid of them by cultivation.

DISEASES

The most destructive alfalfa diseases in the United States include bacterial wilt *Phytophthora insidiosa* (McC.) Bergey et al.); root rot (*Phymatotrichum omnivorum* (Shear) Duggar); crown wart (*Uromyces alfalfae* (Lagh.) Magn.); leaf spot (*Pseudopeziza medicaginis* (Lib.) Sacc.); yellow leaf blotch (*Pyrenopeziza medicaginis* Fekl.); and "alfalfa dwarf."

Bacterial wilt is regarded as the most serious disease attacking alfalfa at the present time. It is quite generally distributed but is especially destructive in some of the best alfalfa districts of the Middle West and West. It is much less prevalent in the extreme

East. Where the disease is serious, stands of alfalfa seldom survive more than 2 or 3 years. The only known means of controlling the disease is to use resistant alfalfas such as Turkistan, Hardistan, Ladak, and Kaw.

Root rot results from a fungous parasite upon the roots of alfalfa, causing the plants to die out in well-defined, usually circular areas, which gradually increase in size. It occurs from eastern Texas to southern California and is the disease which attacks cotton and other taprooted plants. Land on which the root rot occurs should be planted to some fibrous-rooted crops, such as corn, sorghum, or some small grains, for several years until the fungus disappears.

Crown wart has been observed on the prairie limestone soils of Mississippi and in many of the States west of the Mississippi River, but it occurs in the greatest abundance in California. The disease is characterized by the appearance of galls on the crown at the base of the stems. These galls, which are caused by a fungus, are much warted externally and vary in size from one eighth to 3 or 4 inches in diameter. Affected plants are seldom killed outright; but the growth is checked and the plants weakened, and smaller yields result. Where the disease becomes serious the land should be plowed and put into some other crop until the gall fungus is eliminated.

Leaf spot is a fungous disease, which is very common where alfalfa is grown and may develop in all conditions of soil and weather. It is more destructive in humid than in dry sections. The disease is characterized by small brown spots about the size of a pinhead which are present on both sides of the leaves. Badly affected leaves turn yellow and drop off, thus reducing the yield and feeding value of the hay. Where the field becomes very badly infected with the disease it is recommended that the crop be cut and removed.

Yellow leaf blotch is also a fungous disease which is common in all large alfalfa-growing regions of the United States. The disease attacks the leaves and is characterized by long yellow blotches which are sprinkled with minute brown dots. Where it is serious it is best to cut the crop.

"Alfalfa dwarf" is the name applied to a disease resembling bacterial wilt, the cause of which has not as yet been determined. This disease is quite serious in parts of southern California, particularly south of the Tehachapi Mountains, and may destroy a stand in 2 or 3 years.

Rust is quite prevalent on alfalfa during some seasons and where abundant tends to check the growth and to cause shedding of the leaves. When such a condition develops the alfalfa should be cut.

INSECTS¹

It is probable that grasshoppers do more damage to alfalfa than any other insect. They occur in all parts of the country but are most often destructive in the arid and semiarid districts. The most effective means of control is the use of poisoned-bran mixtures. The

¹ Contributed by the Bureau of Entomology, U.S. Department of Agriculture.

formula generally recommended is made up as follows: Coarse wheat bran, 100 pounds; crude arsenic, 5 pounds; cane molasses, $1\frac{1}{2}$ gallons; water, 10 to 12 gallons. The bran is spread out on a tight floor or in a wagon box or similar container to a depth of 8 to 10 inches. The required quantities of water, arsenic, and molasses are mixed thoroughly in a large can or barrel. This mixture is then splashed over the bran, about 3 gallons at a time, and the bran is worked into a mash by turning it over with a scoop shovel, potato fork, or garden rake. The liquid must be stirred constantly, as otherwise the poison soon settles out. About 200 pounds of bran is all that can easily be mixed in a wagon box at one time, but on a floor where there is plenty of room about 500 pounds can be handled. Good results depend on mixing the mash thoroughly until it contains no lumps and is moist throughout. It should fall in flakes when scattered with the hand. More detailed directions for the control of grasshoppers can be found in Farmers' Bulletin 1691, How to Control Grasshoppers in Cereal and Forage Crops.

The alfalfa weevil is quite destructive in parts of the West. It made its first appearance in Utah in 1904, and has spread to Idaho, Nevada, Wyoming, and western Colorado, eastern and southern Oregon, the San Francisco Bay district, and the northeastern corner of California. The insects feed on the green leaves and where numerous cause considerable damage. The most effective means of control is to time the cuttings of the crop so that the immature stages of the weevil are killed by exposure to heat immediately following the removal of the crop. Control can also be accomplished by means of a thorough application of calcium arsenate, the powder form being mixed with water to make a spray. The approved formula is 2 pounds of calcium arsenate to 100 gallons of water, this quantity to be applied as a spray to 1 acre of alfalfa. Where this application is made at a time when the growing tips of the plants are beginning to show serious injury from the weevil, it results in complete control of the insect for the current season, subsequent cuttings of the crop usually being practically free from the pest. Further details on the control of the alfalfa weevil can be found in Farmers' Bulletin 1528, The Control of the Alfalfa Weevil.

One of the most serious of all alfalfa troubles is the yellowing of the plants resulting from leaf-hopper attacks. While this seldom kills the plants outright its attacks are doubtless responsible for material reduction in yields of alfalfa, particularly in the Eastern States. Yellow fields should be cut regardless of the stage of development.

There are a number of other insects that do more or less serious damage to alfalfa. Among the more important of these are the alfalfa seed chalcis fly, garden webworms, the clover root borer, the clover root curculio, the clover stem borer, alfalfa aphid, the alfalfa caterpillar, clover leaf weevils, various cutworms and army worms, blister beetles, crane flies, the red harvester ant, thrips, the tarnished plant bug, and the alfalfa looper. Information on the control of these pests can be obtained by applying to the Bureau of Entomology, United States Department of Agriculture.

RODENTS

The most troublesome animal pests encountered in growing a crop of alfalfa are gophers, ground squirrels, prairie dogs, and mice. They are especially troublesome in the western half of the country, where they eat the roots of the plants. Where irrigation waters are available these pests are controlled to some extent by drowning. Poisoning and trapping are the best means of holding them in check, but because of the danger attending the careless use of poisons it is suggested that the farmer get in touch with the county agricultural agent or a representative of the Bureau of Biological Survey of the United States Department of Agriculture whenever these pests become troublesome.